



# A Process Model of Situated Cognition in Military Command and Control

Collaboration and Knowledge Management  
Workshop

11 - 13 January 2005  
San Diego, CA



**Nita Lewis Miller**  
**Naval Postgraduate School**  
**Monterey, CA**

**Lawrence G. Shattuck**  
**United States Military Academy**  
**West Point, NY**

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>JAN 2005</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2005 to 00-00-2005</b>	
4. TITLE AND SUBTITLE <b>A Process Model of Situated Cognition in Military Command and Control</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Naval Postgraduate School, Monterey, CA, 93943</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>Collaboration and Knowledge Management (CKM) Workshop, 11-13 Jan 2005, San Diego, CA</b>					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>42</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			



# Agenda

- ❑ Situation Awareness versus Situated Cognition
- ❑ A Process Model of Situated Cognition
- ❑ The *USS Stark*: A Case Study (Individual)
- ❑ Team versus Shared Situation Awareness
- ❑ The *USS Stark*: A Case Study (Distributed)
- ❑ Measurement Methods and Metrics



## Descriptions of Situation Awareness

“The **perception of elements** in the environment within a volume of time and space, the **comprehension of their meaning**, and **their status** in the near future.” (Endsley, 1988)

“**A common, relevant picture** of the battlefield scaled to specific levels of interests and special needs.”  
(TRADOC Pamphlet 525-5)

“The **product** of applying analysis and judgment to the common operational picture...” (FM 3-0 (Operations))

Ideal SA; Achievable SA; Actual SA  
(Pew, 2000)

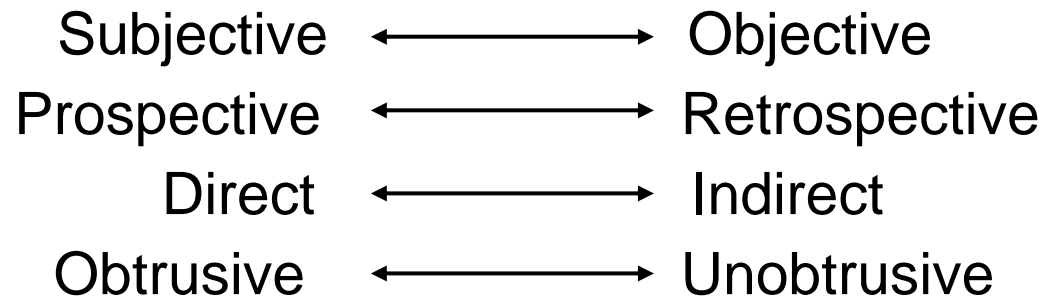
“Where am I? Where’s my buddy?  
Where’s the enemy?” (An Army Officer)

“That’s my SA (pointing to his FBCB2 screen).” (An Enlisted Soldier)

State  
Thing  
Product  
Information



# Methods for Measuring SA



- ❑ SART: Situational Awareness Rating Technique
- ❑ SA-SWORD: Situation Awareness-Subjective Workload Dominance
- ❑ SARS: Situation Awareness Rating Scale
- ❑ MARS: Mission Awareness Rating
- ❑ SAGAT: Situational Awareness Global Assessment Technique
- ❑ SALIENT: SA Linked Instances Adapted to Novel Tasks
- ❑ SABARS: Situation Awareness Behaviorally Anchored Rating Scale

**These methods tend to measure:**

- ❑ **states, not processes**
- ❑ **humans, not systems**



# An Alternative to Situation Awareness



What is needed is a model and a methodology that:

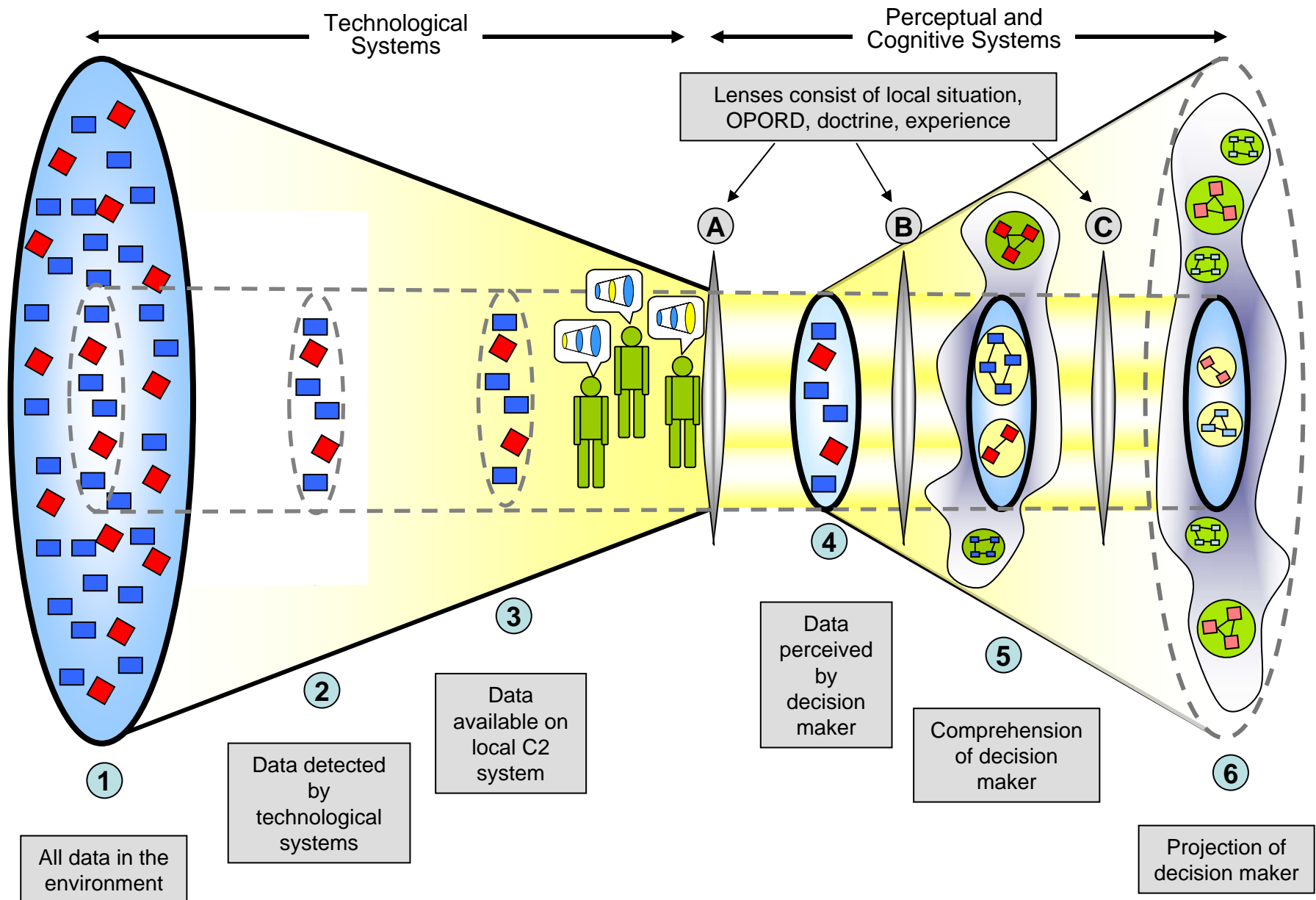
- ❑ focuses on ***processes*** rather than states
- ❑ includes both ***human and machine*** 'components' of a system
- ❑ is oriented on assessing ***human-system performance***
- ❑ tracks the ***evolution*** of activities and cognition



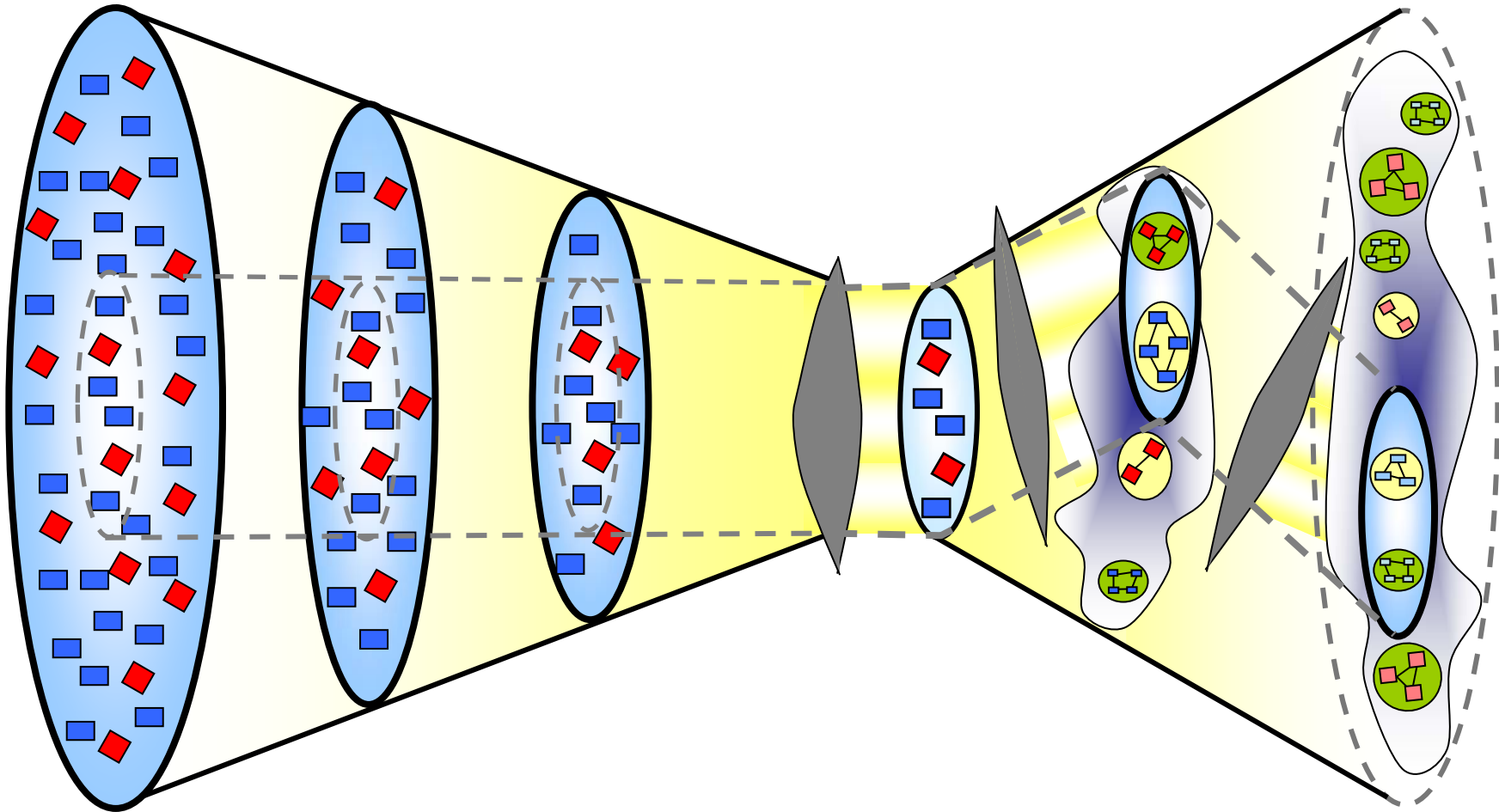
# Situated Cognition

- ❑ Borrowed from the learning and linguistics literature
- ❑ Includes mental activities ***embedded in an evolving context***
- ❑ Includes ***human and machine agents***
- ❑ Involves ***collaborative activities***
- ❑ ***Goal-directed***

# A Process Model of Situated Cognition

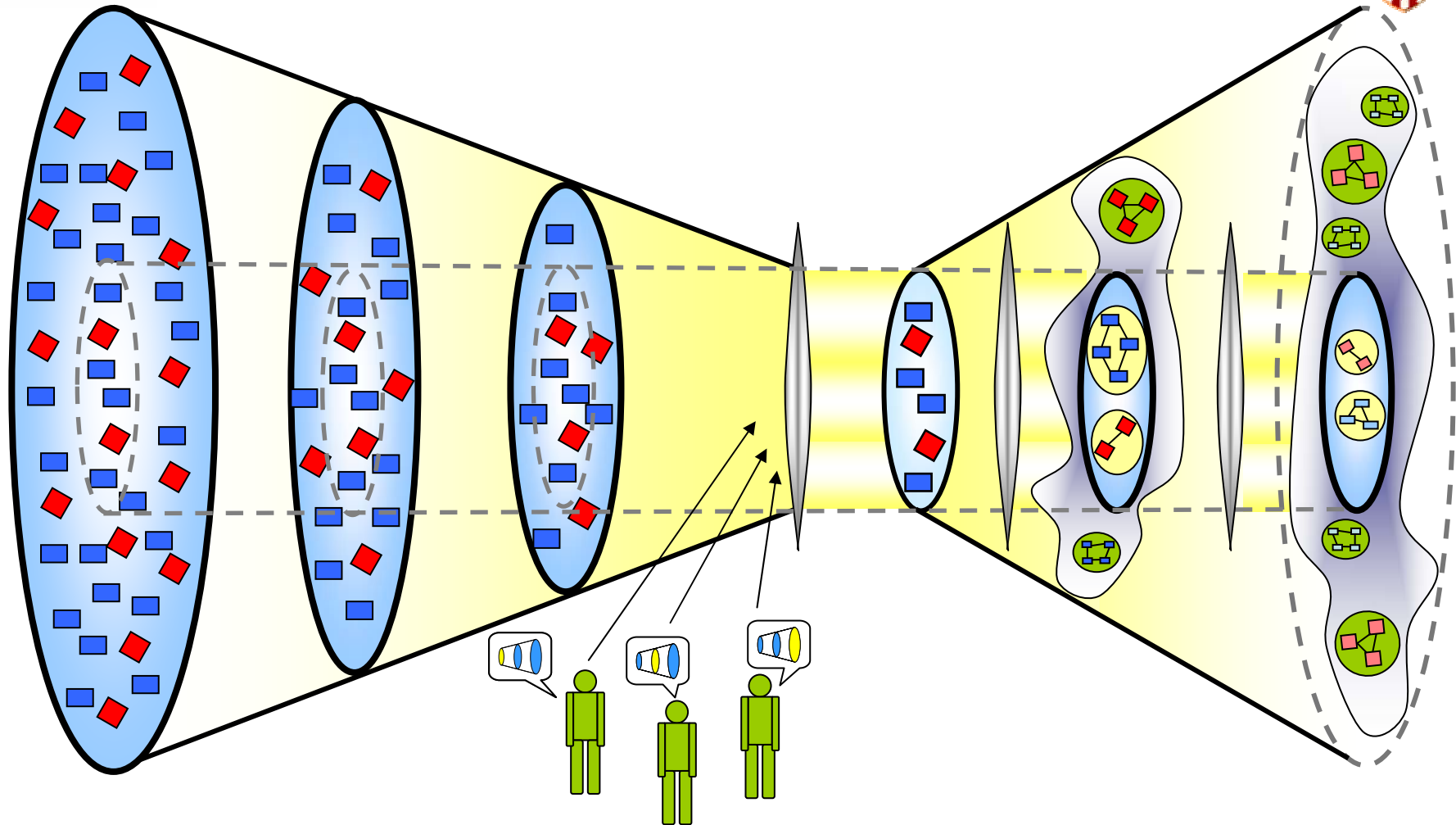


***Misshaped lenses* will skew a decision maker's perceptions, comprehensions, and projections**



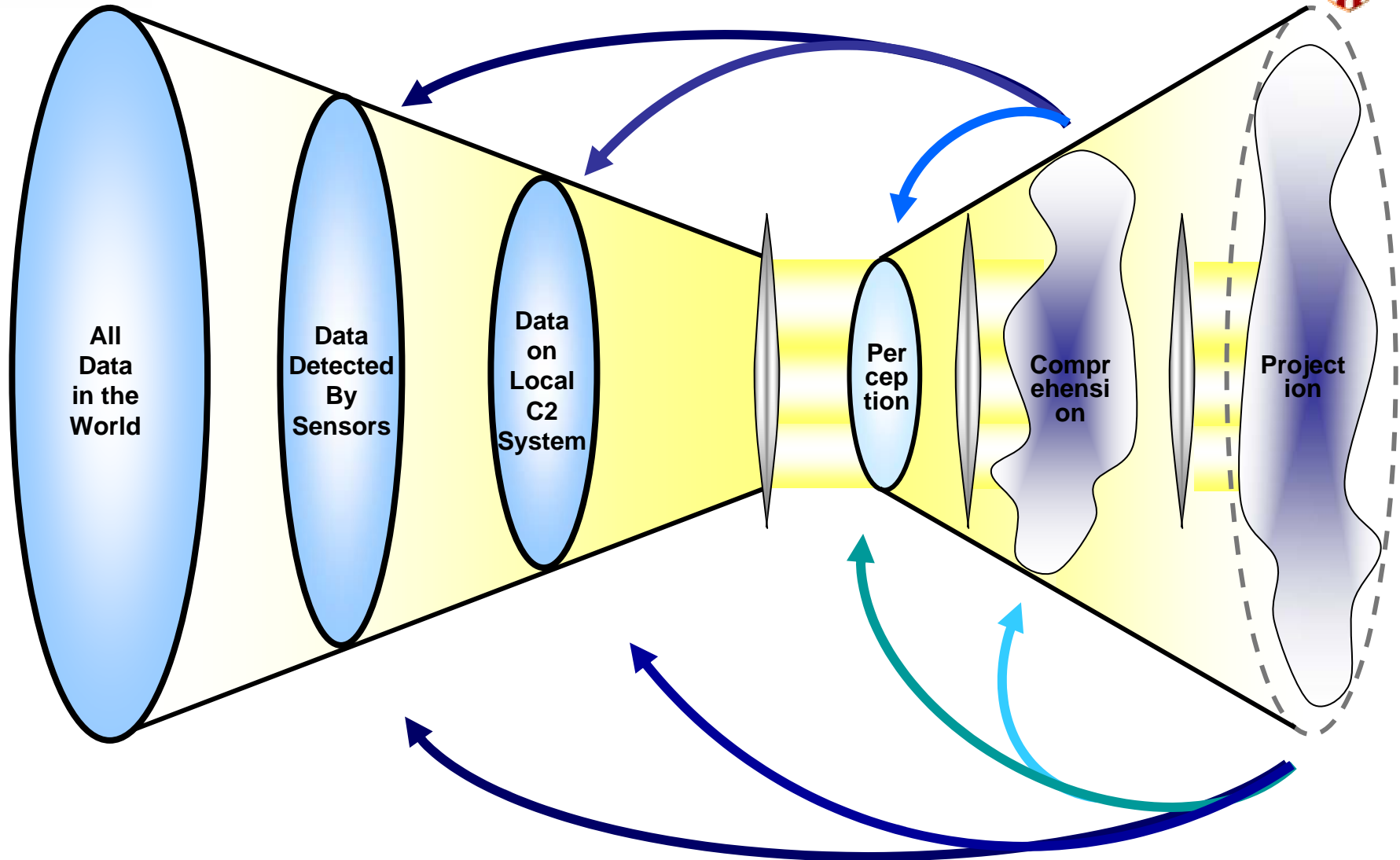


# A Process Model of Situated Cognition



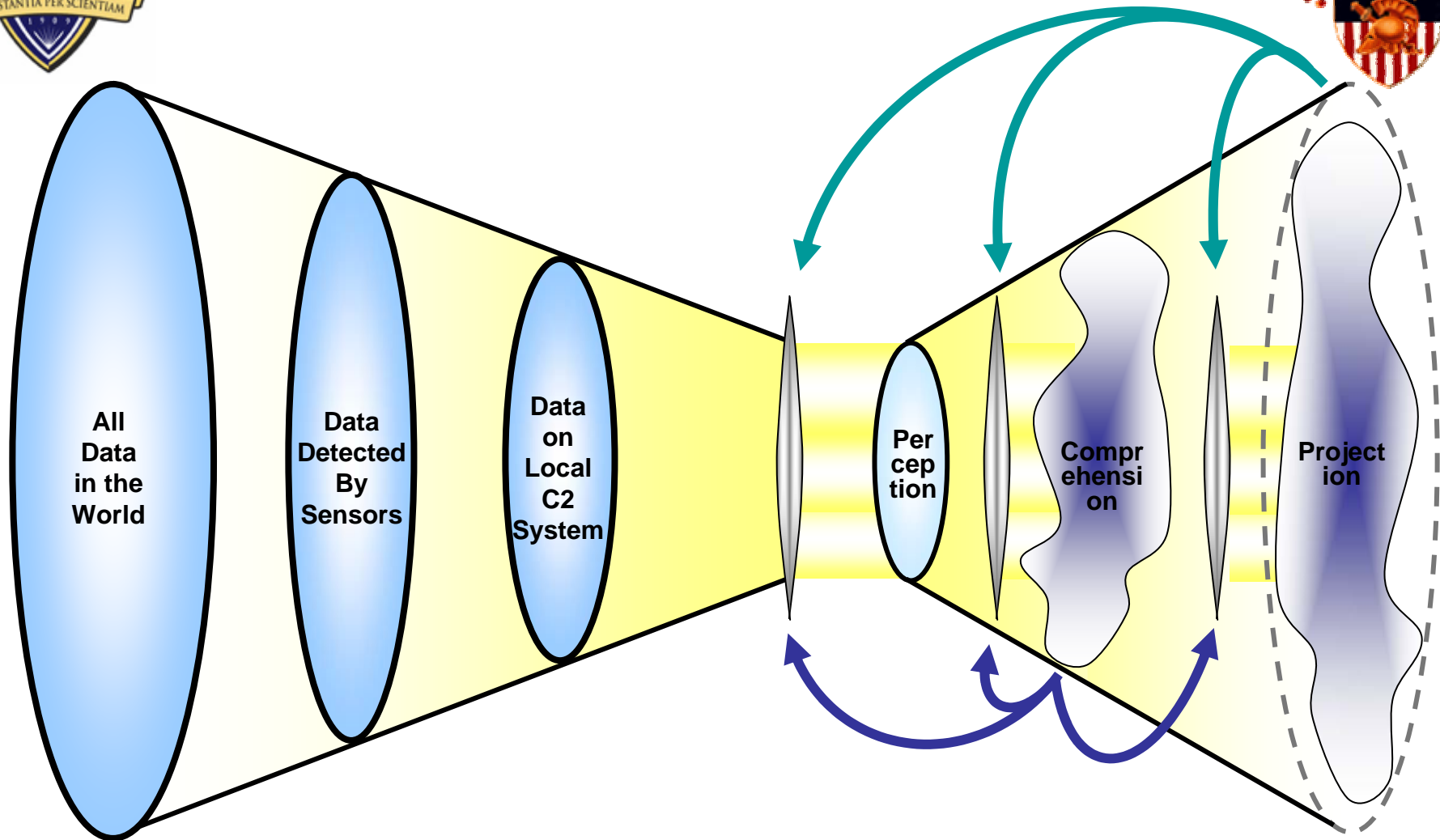


# Feedback Loops in the Model

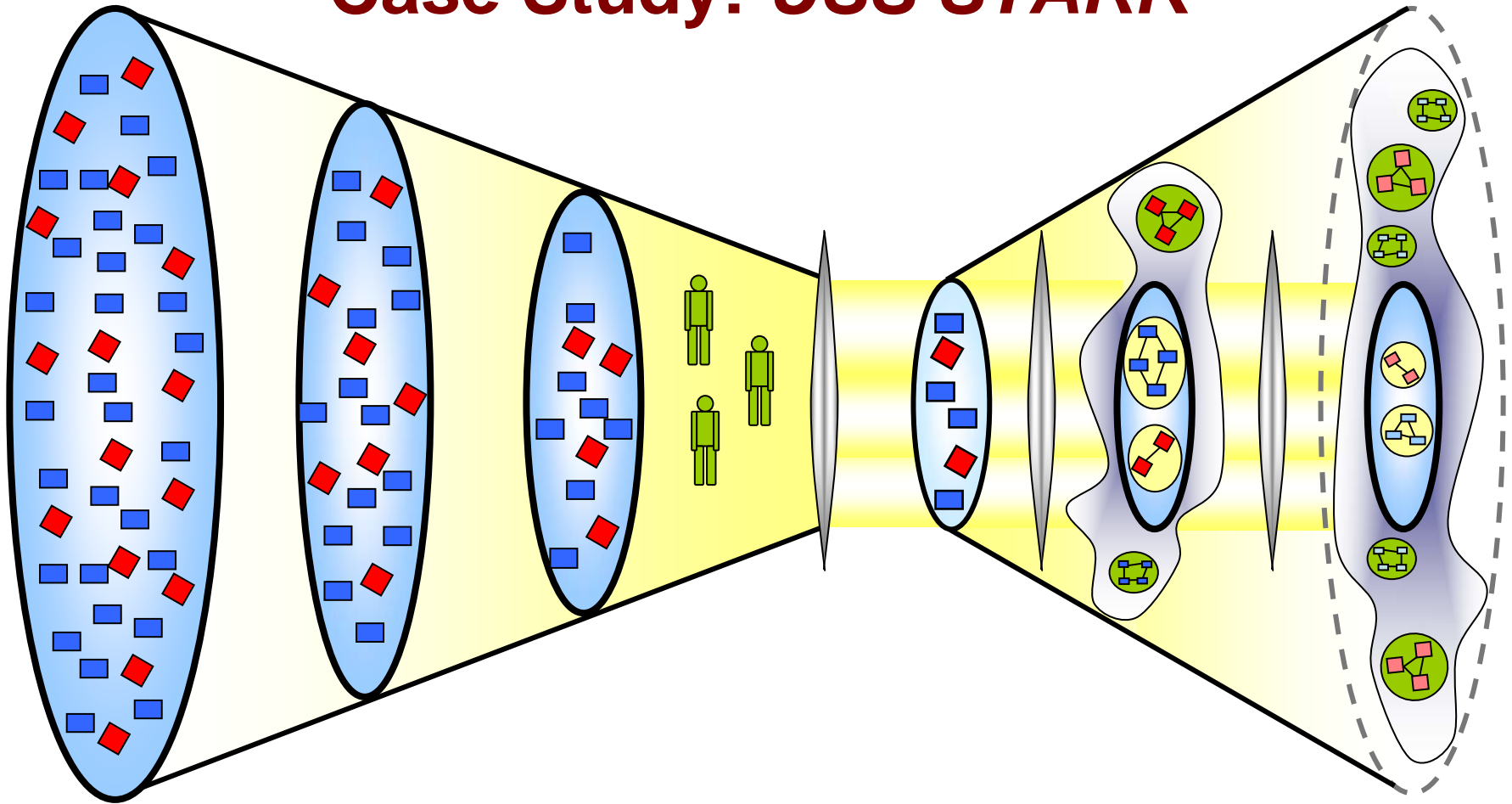




# Feedback Loops in the Model



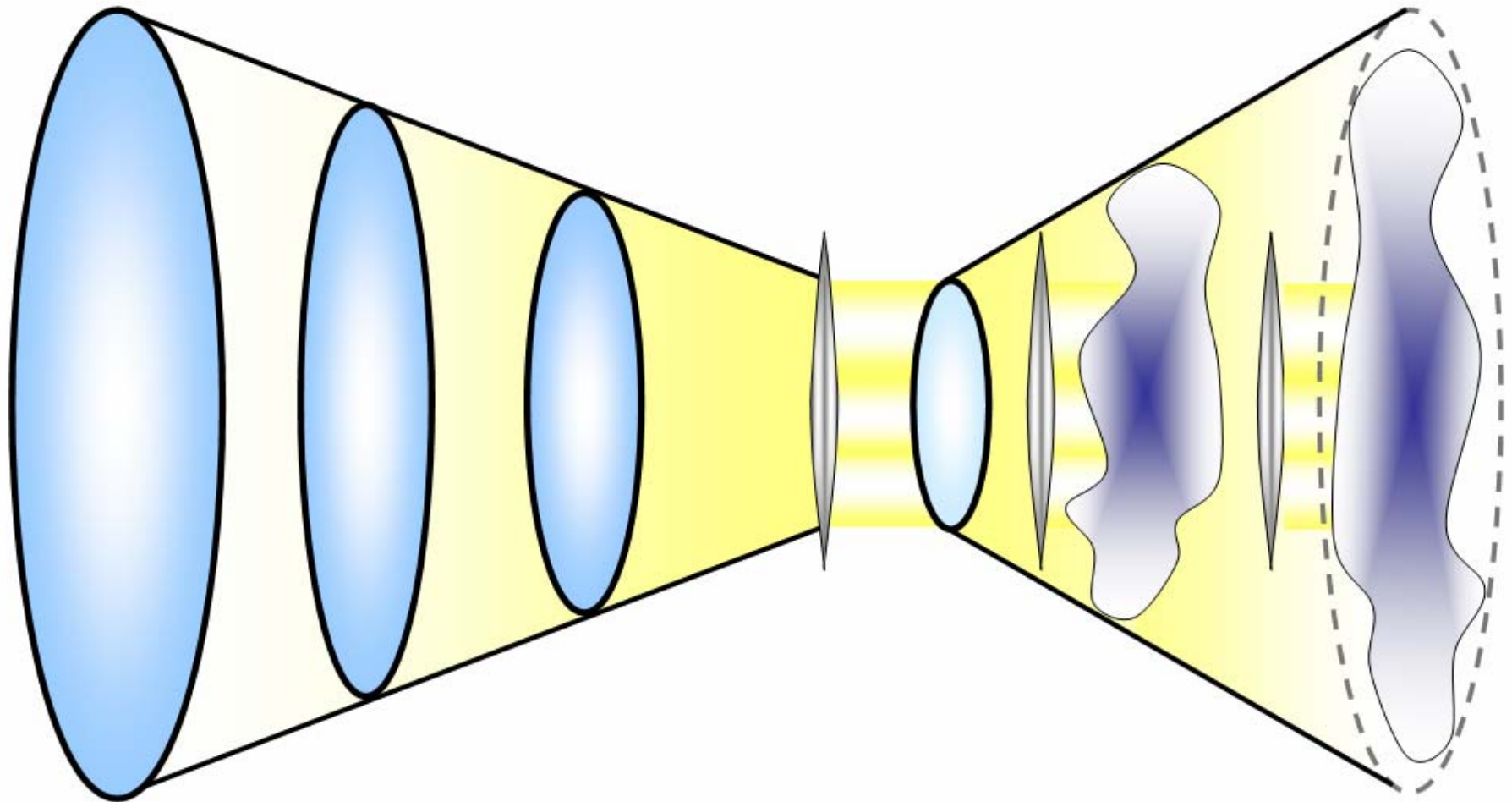
# Case Study: *USS STARK*



On the evening of May 17, 1987, the *USS Stark* was patrolling international waters in the Persian Gulf off the coast of Bahrain and Saudi Arabia. At 2109 that evening, the *USS Stark* was struck by the first of two Exocet AM-39 anti-ship cruise missiles, fired from an Iraqi F-1 Mirage fighter.



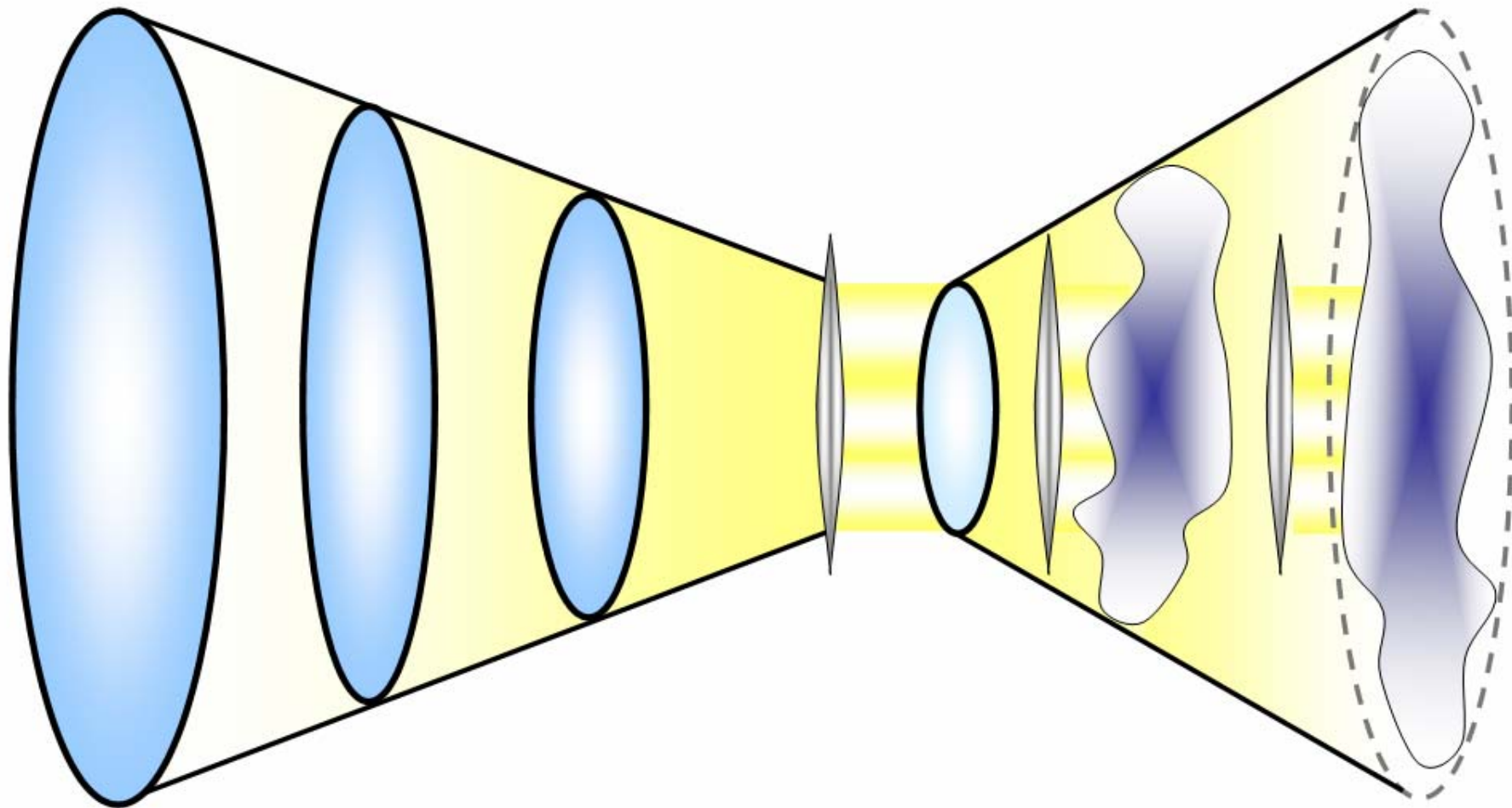
## Oval 1: Ground Truth





## Oval 1: Ground Truth

Stark is 12nm west of Iraqi exclusion zone.

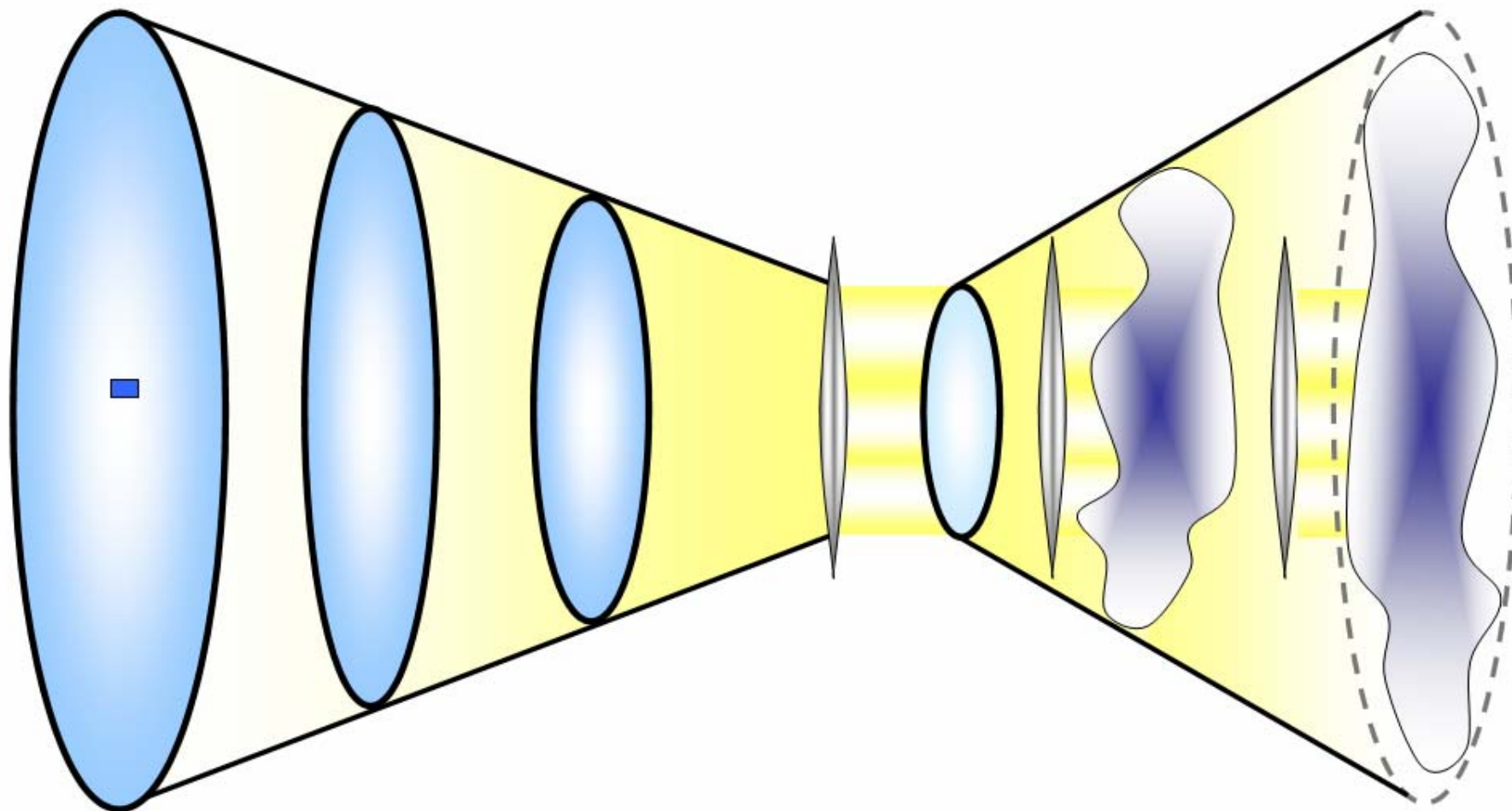




## Oval 1: Ground Truth



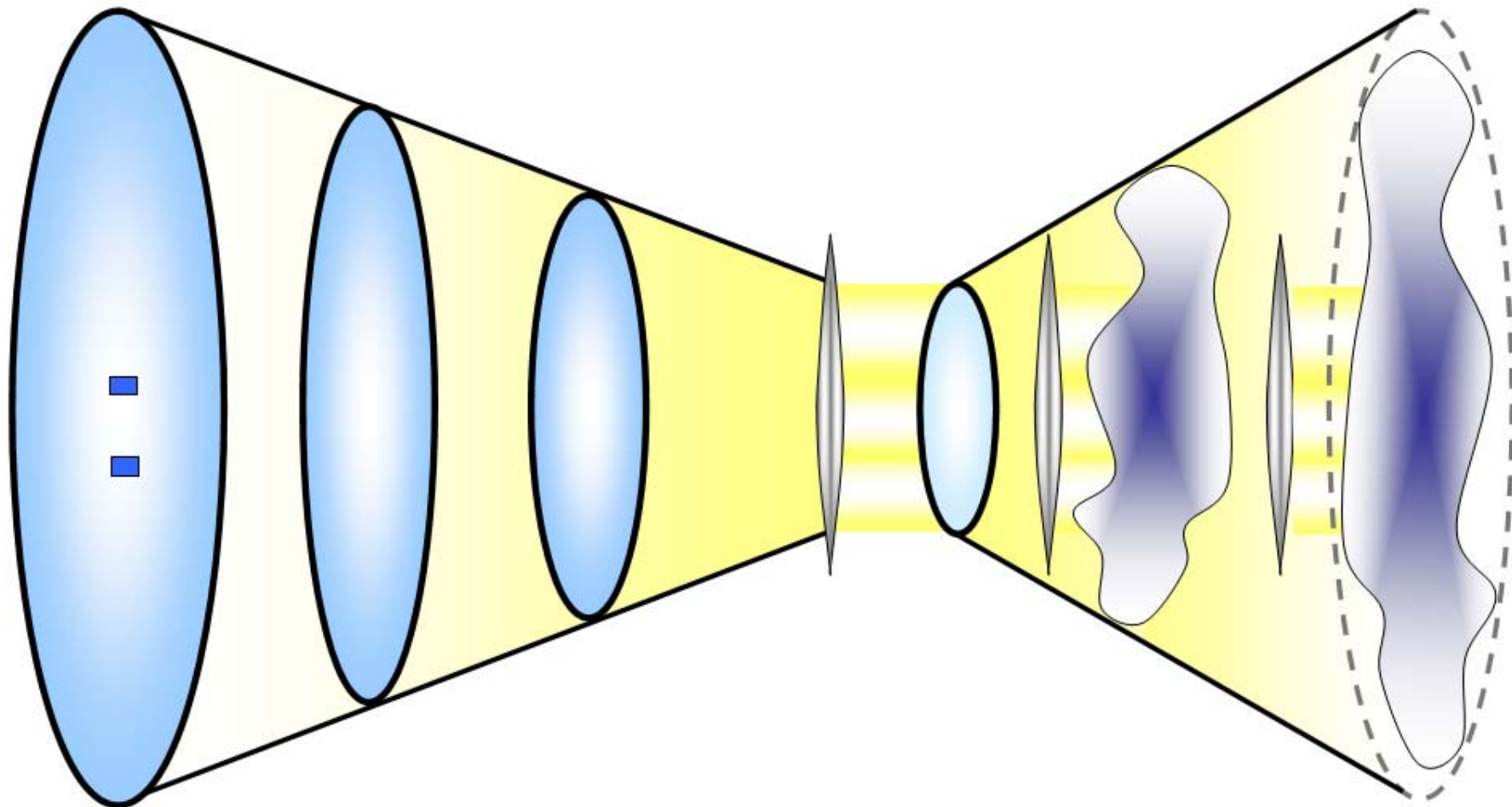
AWACS is aloft.





## Oval 1: Ground Truth

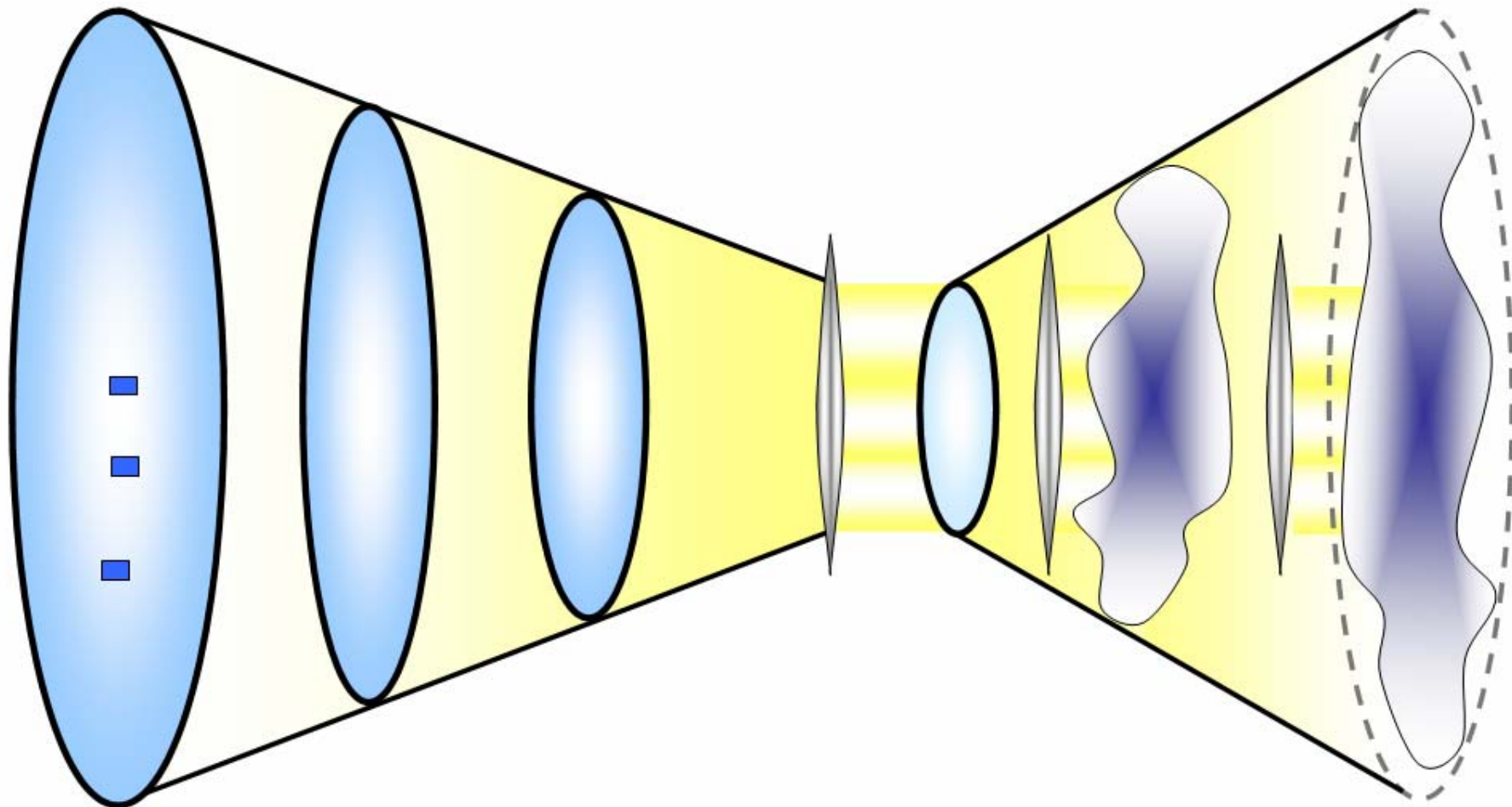
Other USN vessels are in the area.





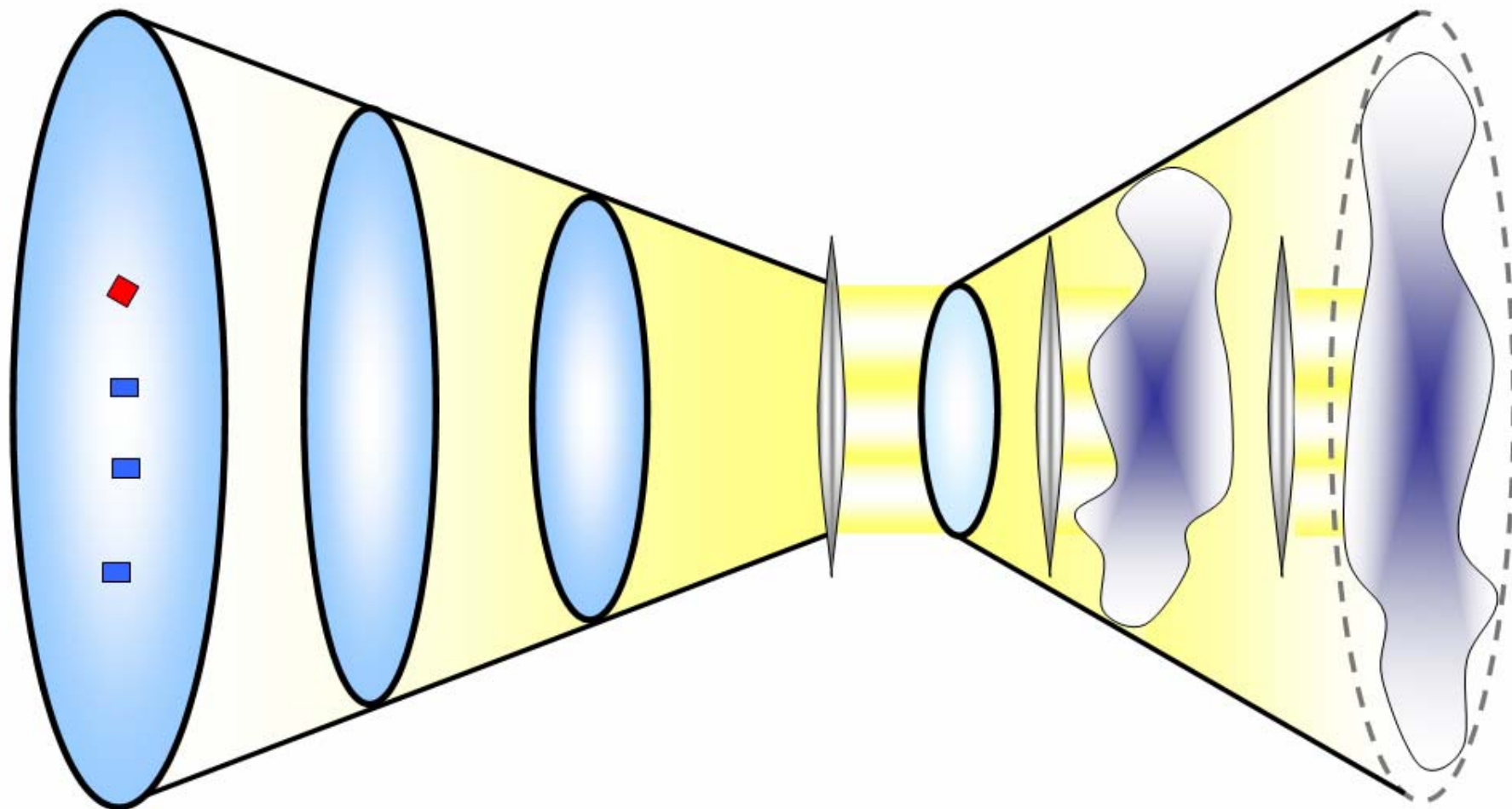
## Oval 1: Ground Truth

Iraqi F-1 Mirage flying toward the *USS Stark*.





## Oval 1: Ground Truth





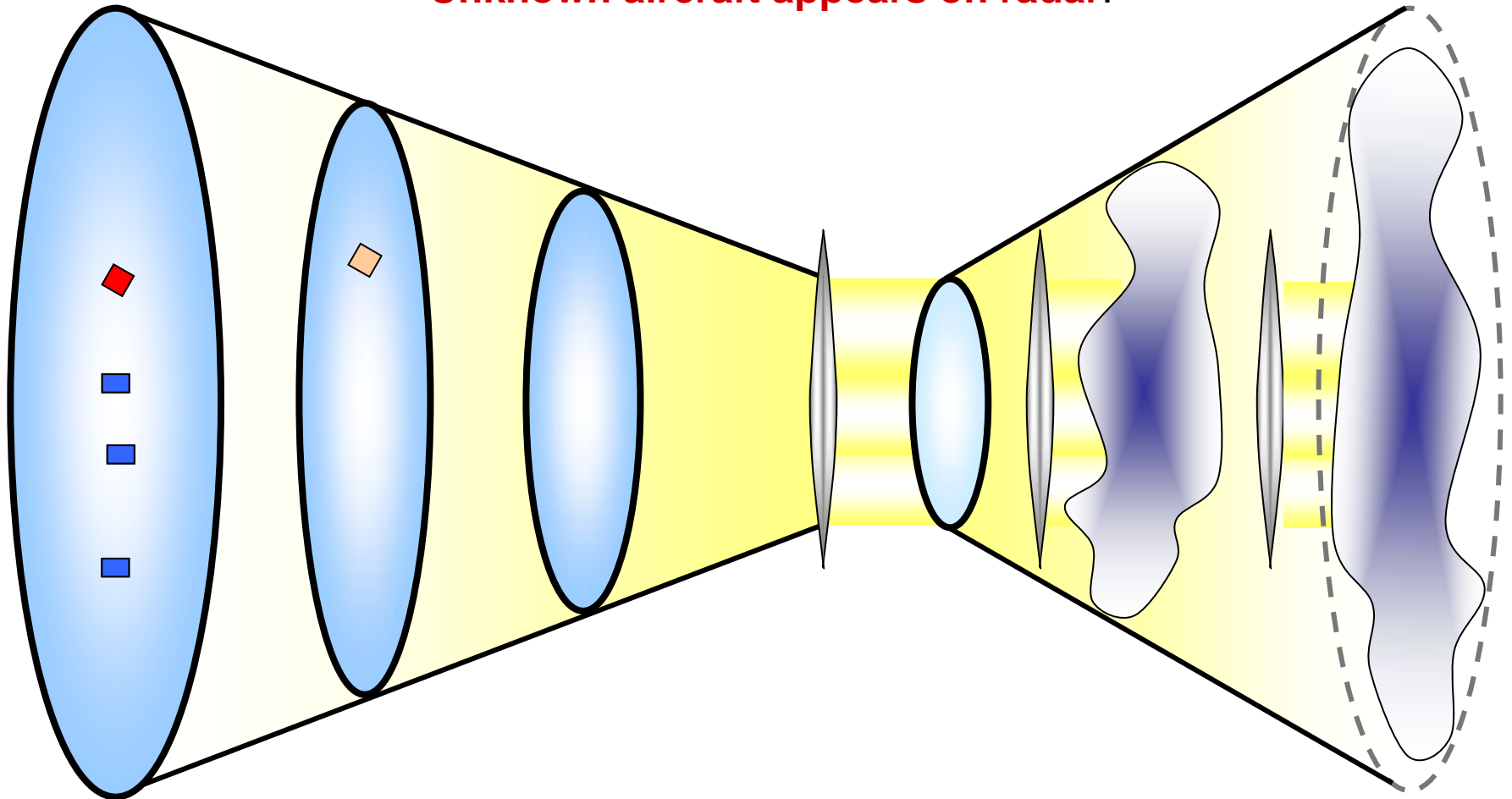
## Oval 2: Sensor Coverage

*USS Stark* is 12 nm from Iraqi exclusion zone.

AWACS is aloft.

Other USN vessels in the area.

**Unknown aircraft appears on radar.**





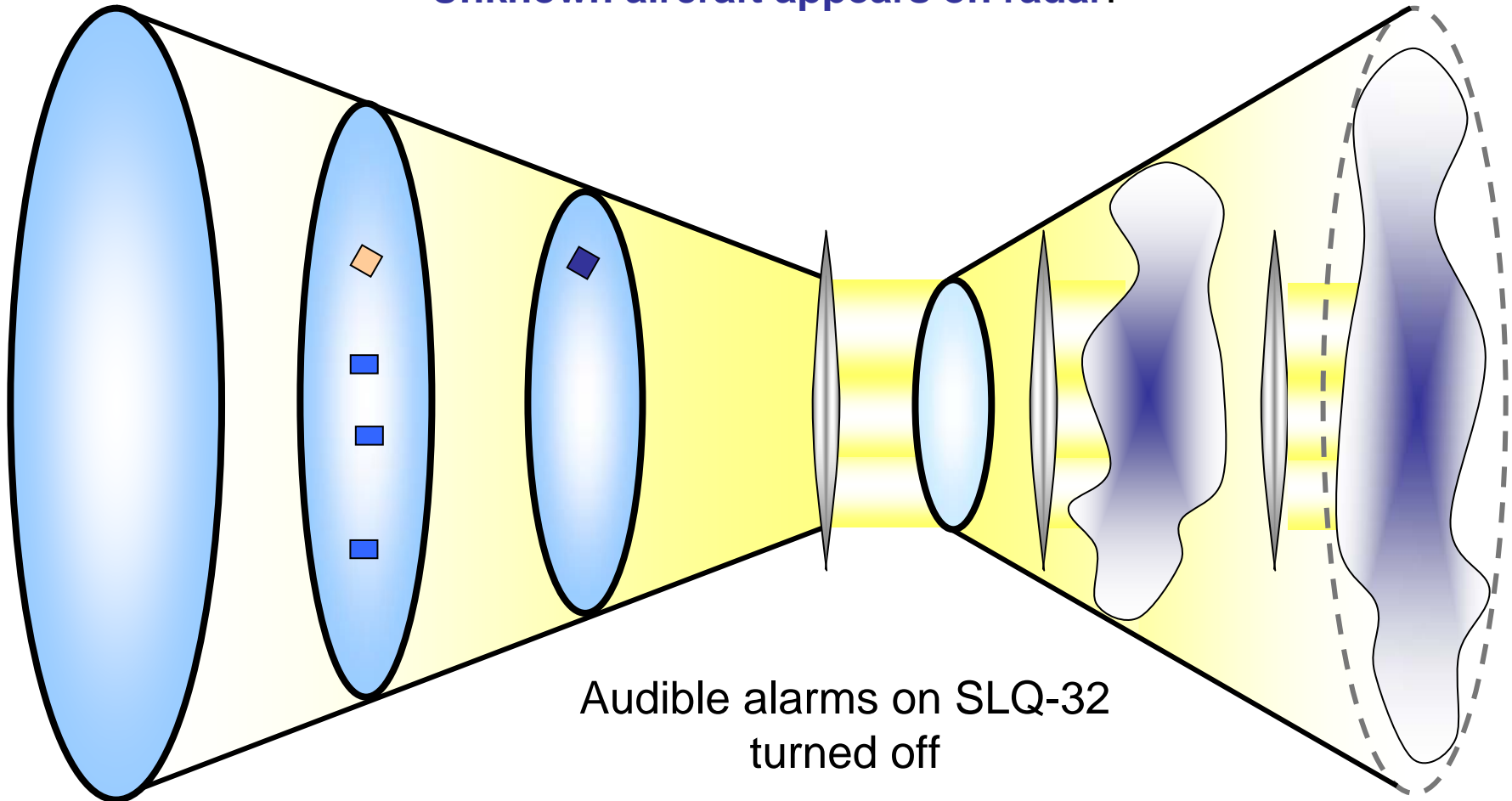
## Oval 3: Workstation Display

*USS Stark* is 12 nm from Iraqi exclusion zone.

AWACS is aloft.

Other USN vessels in the area.

**Unknown aircraft appears on radar.**

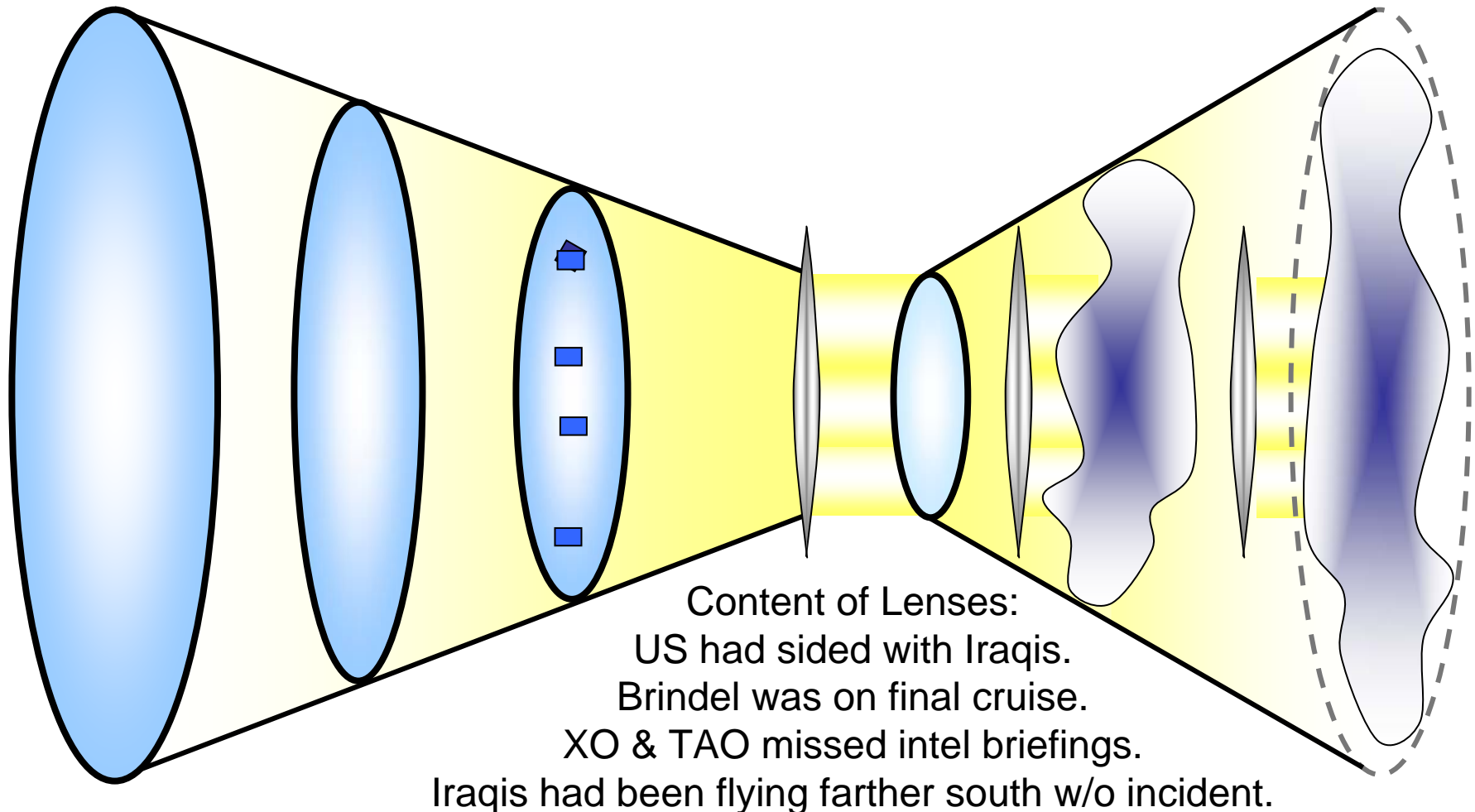


Audible alarms on SLQ-32  
turned off



## Oval 4: Perception

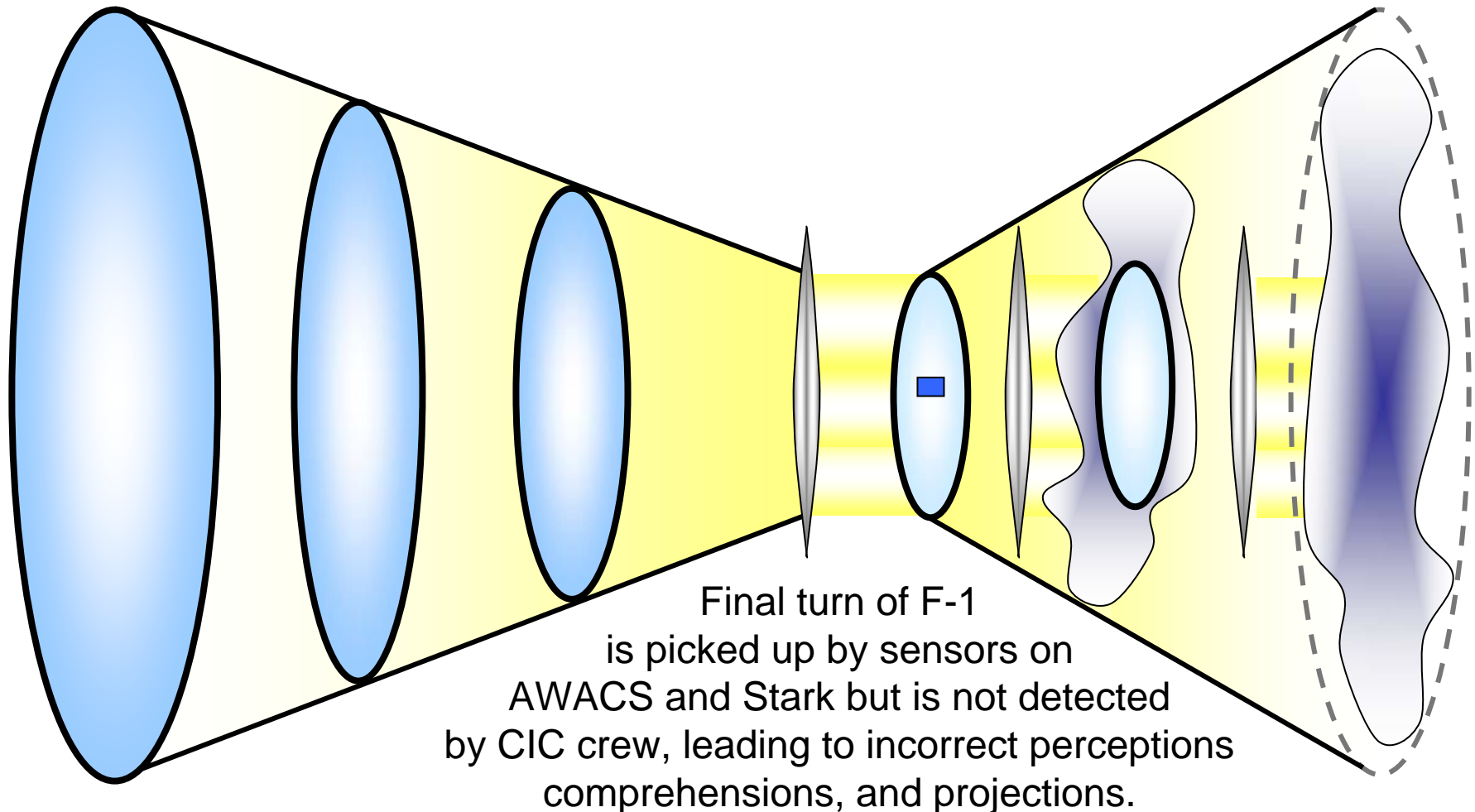
Aircraft on detected on radar.  
Aircraft tagged as friendly.





## Oval 5: Comprehension

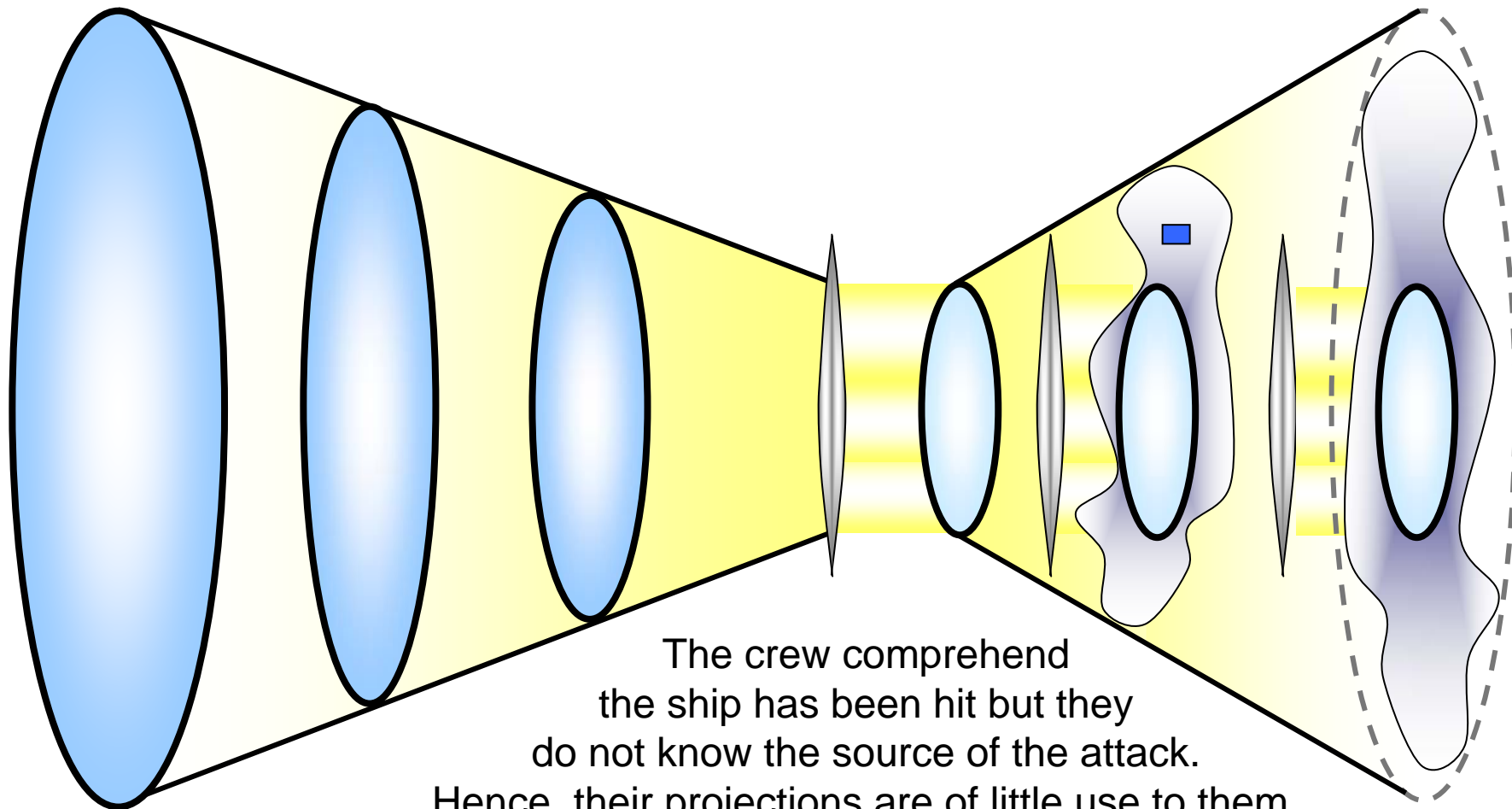
Aircraft is no threat to *USS Stark*.





## Oval 6: Projection

Aircraft will turn away from *USS Stark*.

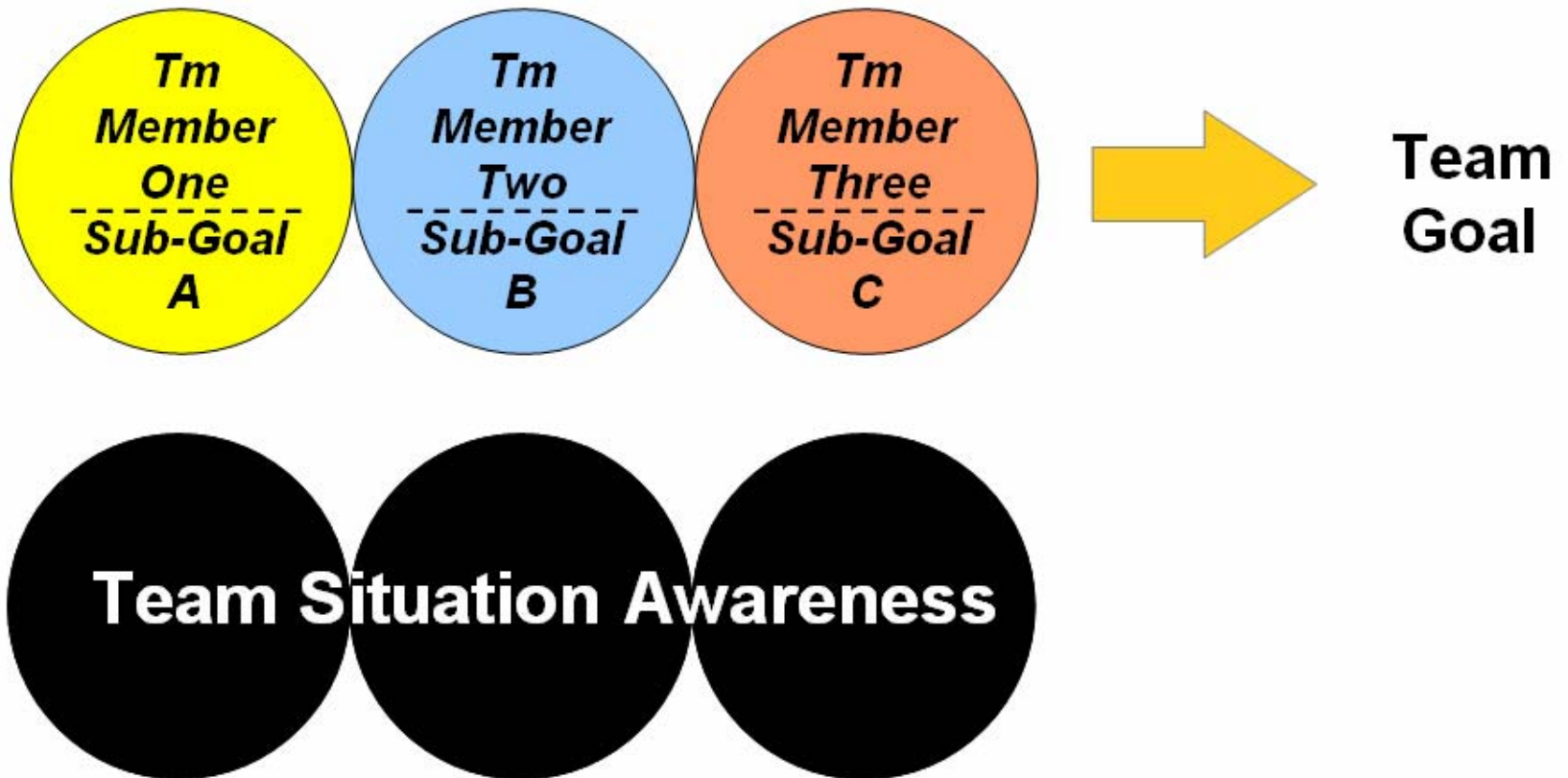


The crew comprehend  
the ship has been hit but they  
do not know the source of the attack.  
Hence, their projections are of little use to them.



# Team Situation Awareness

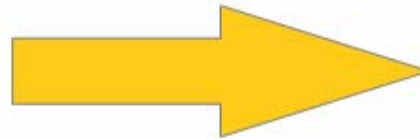
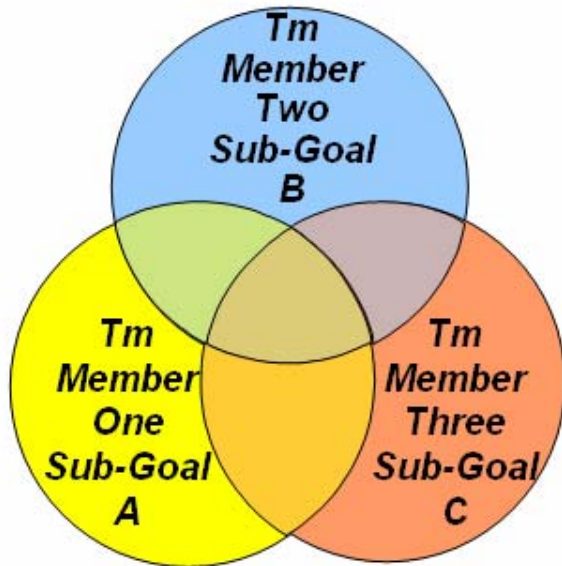
The degree to which all team members possess the SA required for their jobs.





# Team Situation Awareness

The degree to which all team members possess the SA required for their jobs.



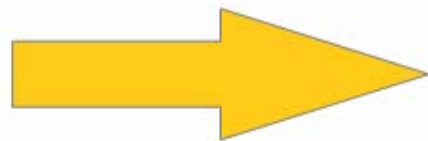
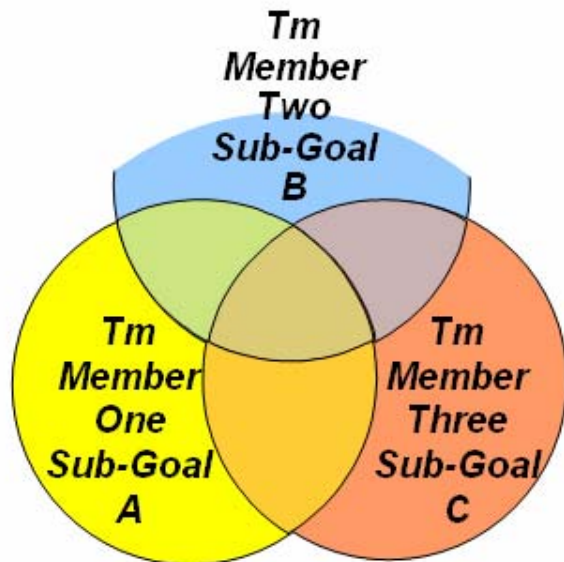
**Team Goal**





# Team Situation Awareness

The degree to which all team members possess the SA required for their jobs.



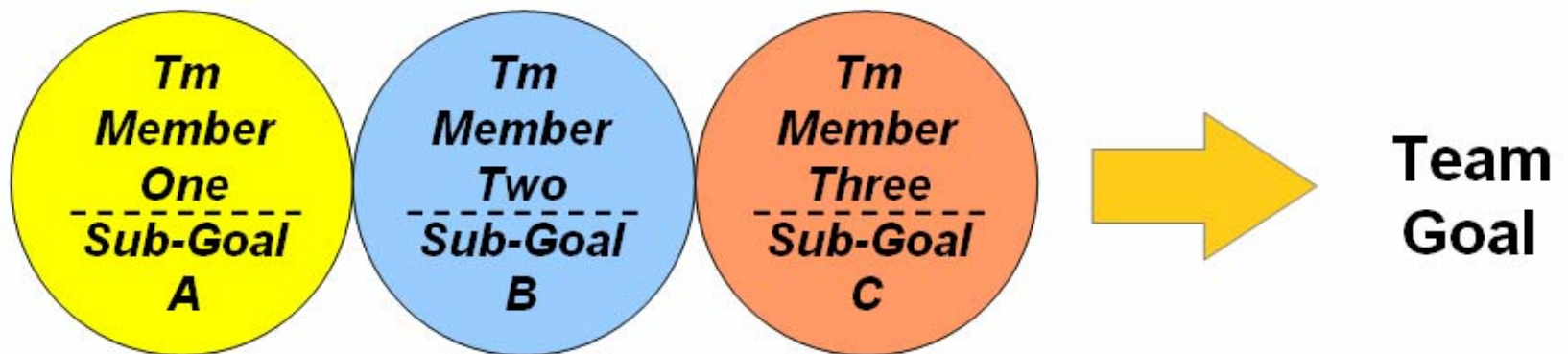
**Team Goal???**





# Shared Situation Awareness

The degree to which team members possess the same SA.

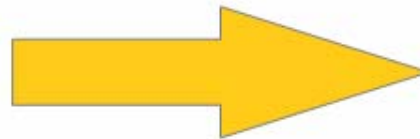
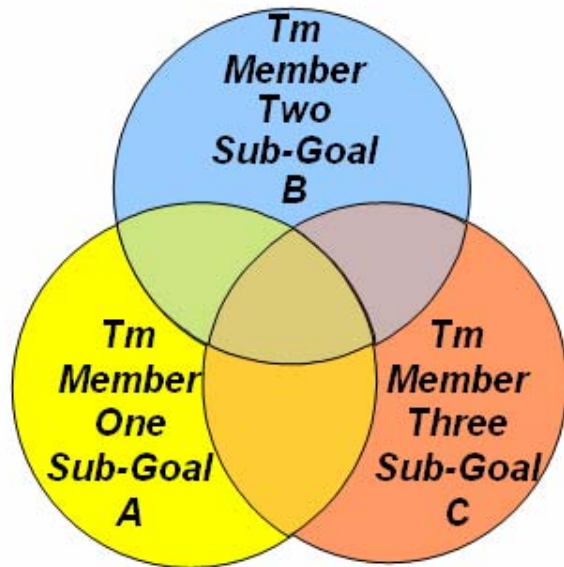


**No Shared Situation Awareness**



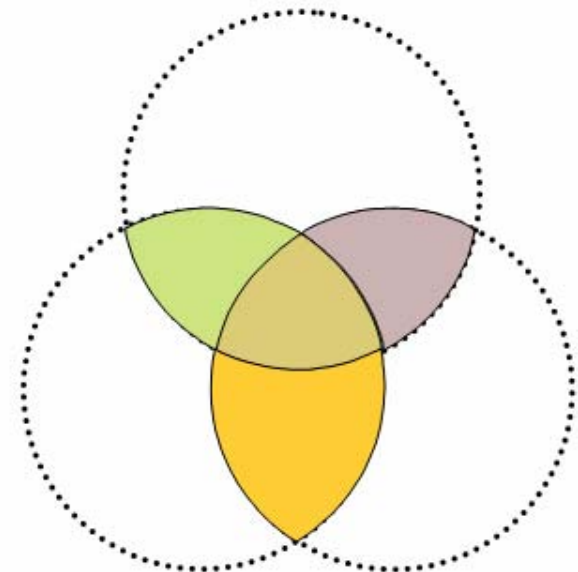
# Shared Situation Awareness

The degree to which team members possess the same SA.



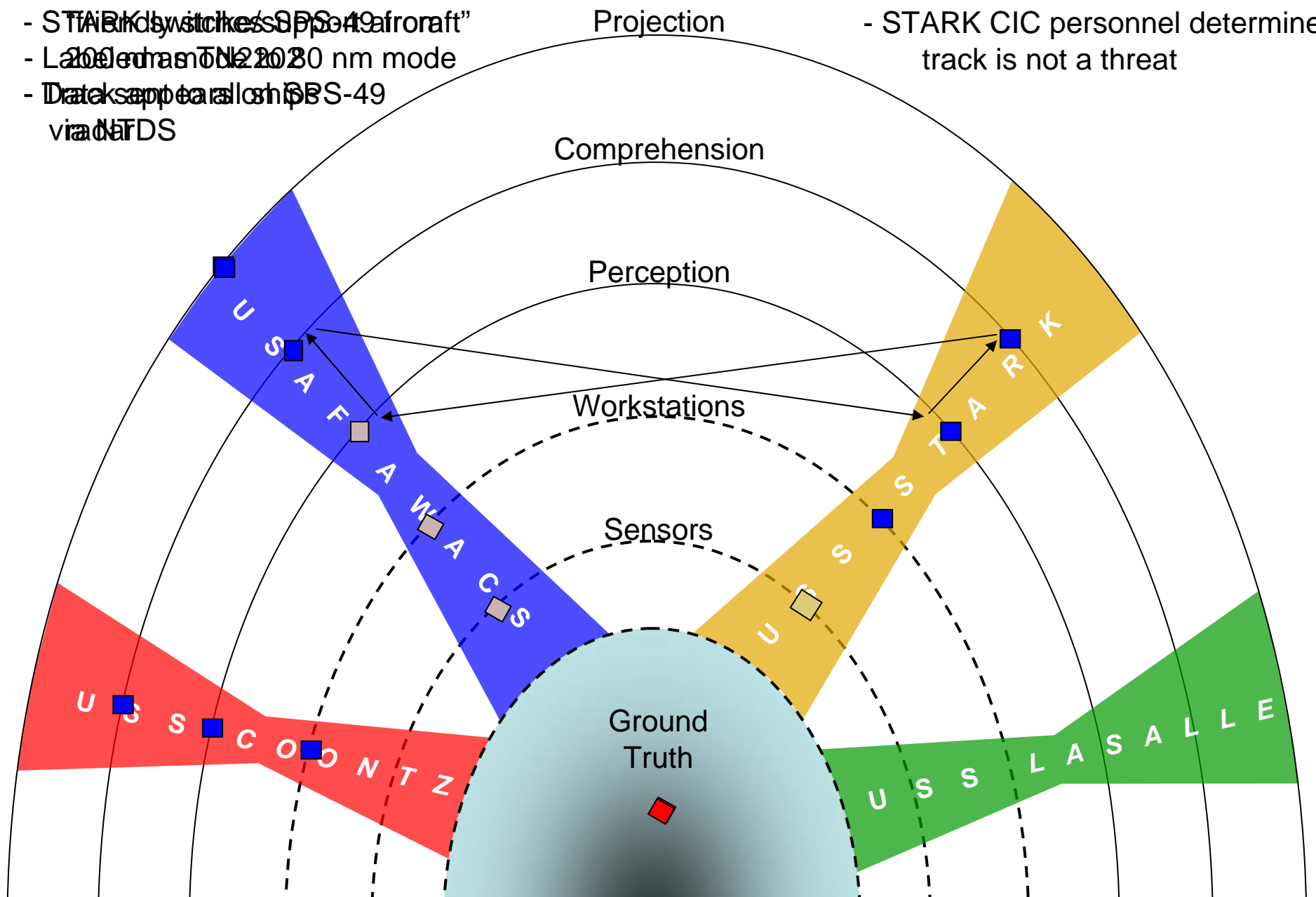
**Team Goal**

**Shared  
Situation  
Awareness**



195500Z also detects track  
- CONUSZ confirms ONE7 on LASALLE  
- AWACS track evaluates as  
- STARK switches OPS-49 aircraft  
- Lantcom TNE22020 nm mode  
- Data appears on SBS-49  
via NTDS

- STARK CIC detects track  
- STARK CIC confirms track with  
AWACS  
- STARK CIC personnel determine  
track is not a threat





# Process Tracing

- ❑ Maps out how the incident unfolded
- ❑ Focuses on how a given outcome came about
- ❑ Externalizes internal processes
- ❑ Uses data from multiple sources
- ❑ Describes the sequence of information flow and knowledge activation

(After Woods, 1993)



# Metrics for Situated Cognition



## Technological side of model:

- Playback of ground truth using various sources (e.g., database queries, screen captures)

## Human side of model:

- Individual characteristics of sensemakers
  - Experience and training (including proficiency with computers and technology)
  - Personality, Intellect
  - Index of Learning Styles
- Behavioral Analysis (direct observation, voice and A/V Recordings)  
Noldus System for Behavioral Capture and Analysis
- Physiological measures of participants (Head and Eye movements, heart rate variability, EEGs)
- Geographical Recall and Analysis of Data in the Environment (GRADE)
- Cued Retrospective Interviews



# Evaluating Data Sources

**Subjective**

SART

SWAG-C

GRADE

Retro Interviews

**Objective**

Audio/Video

Wrist Monitors

HR Monitors

Dbase Queries

**Obtrusive**

GRADE  
SART

Retro Interviews  
SWAG-C

Wrist Monitors

HR Monitors

Audio/Video  
Dbase Queries

**Unobtrusive**

**Data**

Dbase Queries

Audio/Video

GRADE

Retro Interviews

**Oval**

1, 2

2, 3, 4, 5, 6

4, 5, 6

4, 5, 6

**Data**

SWAG-C

HR Monitors

SART

Wrist Monitors

**Oval**

4, 5

4, 5

4, 5, 6

4



# GRADE

## (Geographical Recall and Analysis of Data in the Environment)

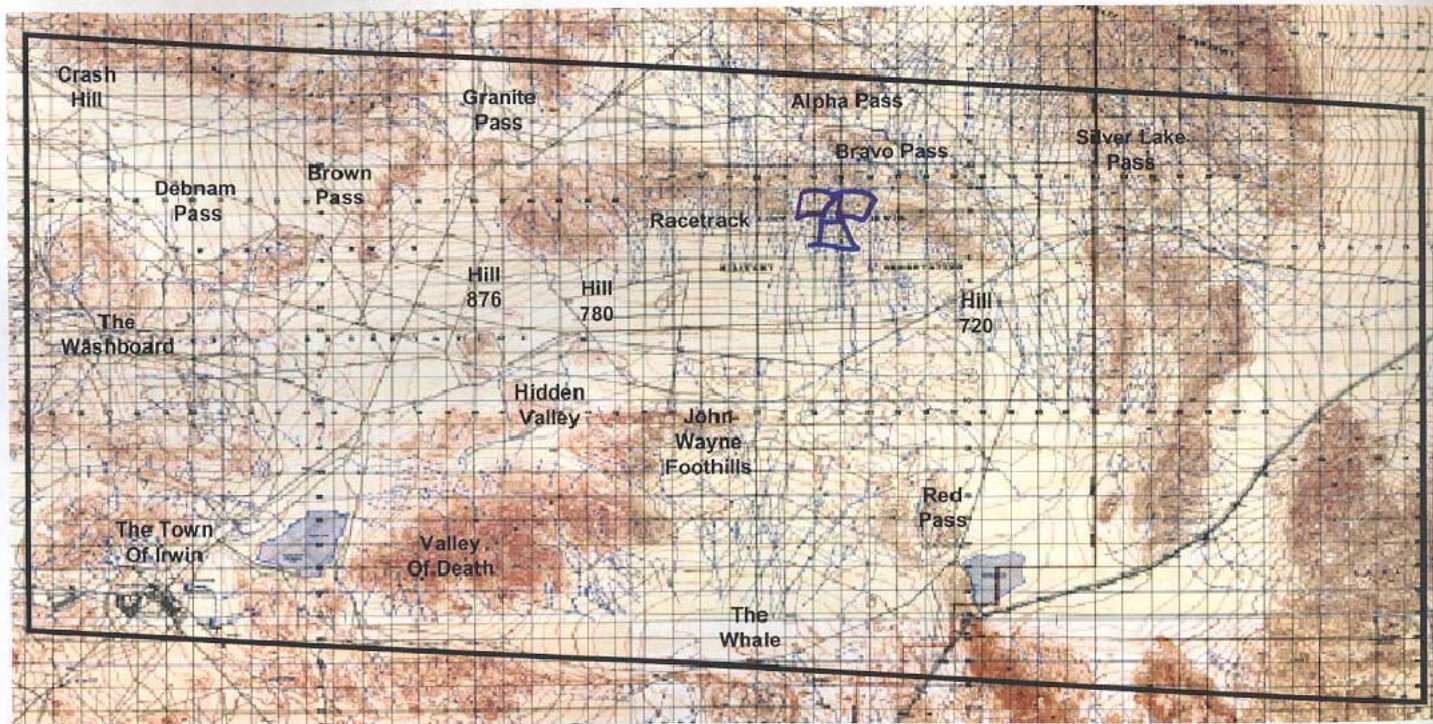
- Not a memory test. A way to gauge where the officer is focused at that moment.
- Facilitates comparison between Oval 3 (what is displayed on local workstation) and Oval 4 (what is perceived by the decision maker).
- On cue participants turn away from the screen.
- “As quickly as possible, sketch the portion of the battlefield on which you are currently focused in sufficient detail to communicate it to a fellow staff officer.”
- Flip an acetate overlay
- “Tell me what the battlespace will look like 30 minutes from now.”
- Number and timing of GRADE events based on scenario.



# Sample GRADE

## INSTRUCTIONS

1. Fill in your SART ratings below. (Refer to descriptions on the inside cover of this binder if necessary.)
2. On the paper map, as quickly as possible, sketch the portion of the battlefield on which you are currently focused in sufficient detail to communicate it to a fellow staff officer.
3. Flip the acetate overlay.
4. On the acetate overlay, sketch what the battlespace will look like 30 minutes from now.



Demand (1 to 7) 2

Supply (1 to 7) 6

Understanding (1 to 7) 2



# Sample GRADE



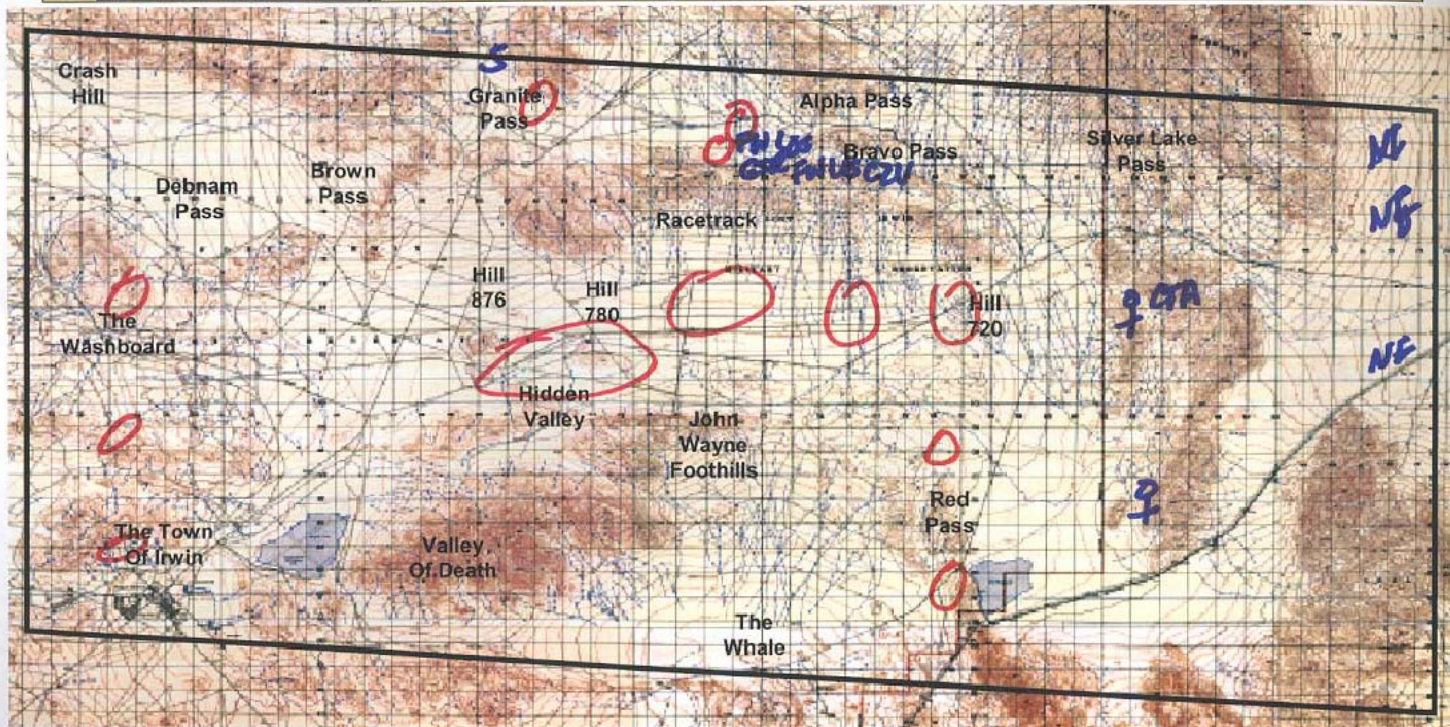
Seat \_\_\_\_

Date: \_\_\_\_

Time: \_\_\_\_

## INSTRUCTIONS

1. Fill in your SART ratings below. (Refer to descriptions on the inside cover of this binder if necessary.)
2. **On the paper map**, as quickly as possible, sketch the portion of the battlefield on which you are currently focused in sufficient detail to communicate it to a fellow staff officer.
3. Flip the acetate overlay.
4. **On the acetate overlay**, sketch what the battlespace will look like 30 minutes from now.



Demand (1 to 7) 5

Supply (1 to 7) 6

Understanding (1 to 7) 5



# GRADE

(Adapted for Trident Warrior '04)

## Experimental Design

USS TARAWA

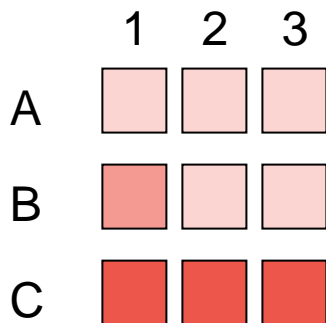
USS JPJONES

USS Pearl Harbor

TAO

ESG

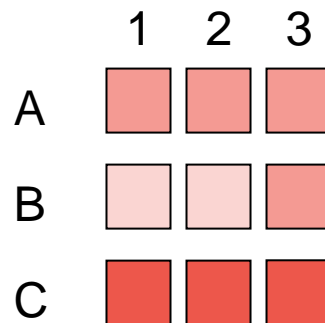
PHIBRON



TAO

ESG

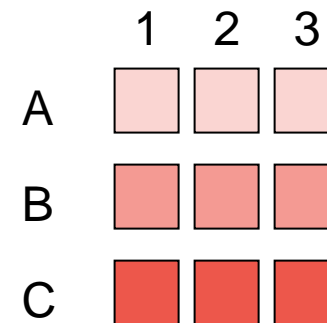
PHIBRON



TAO

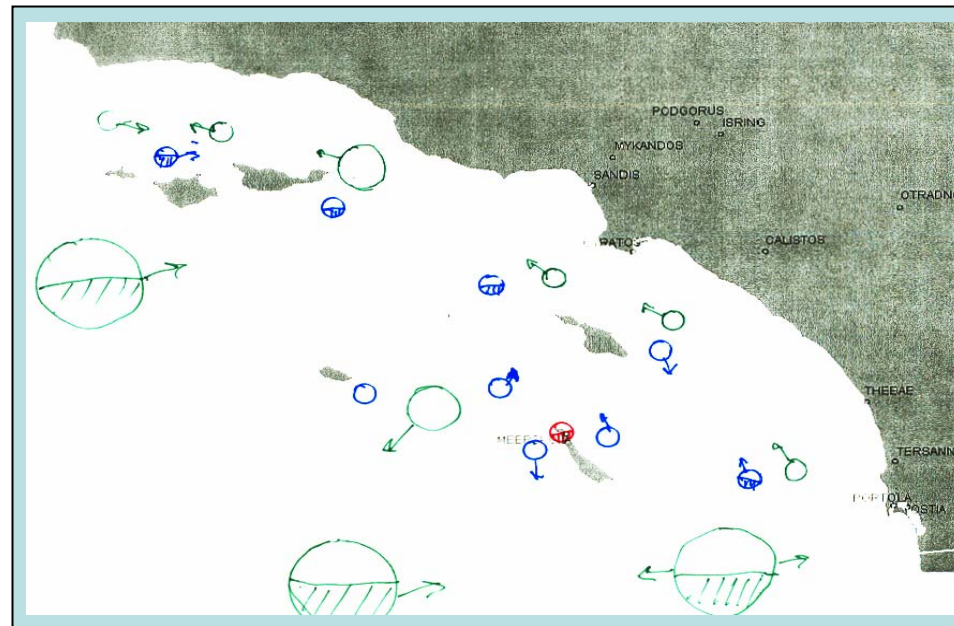
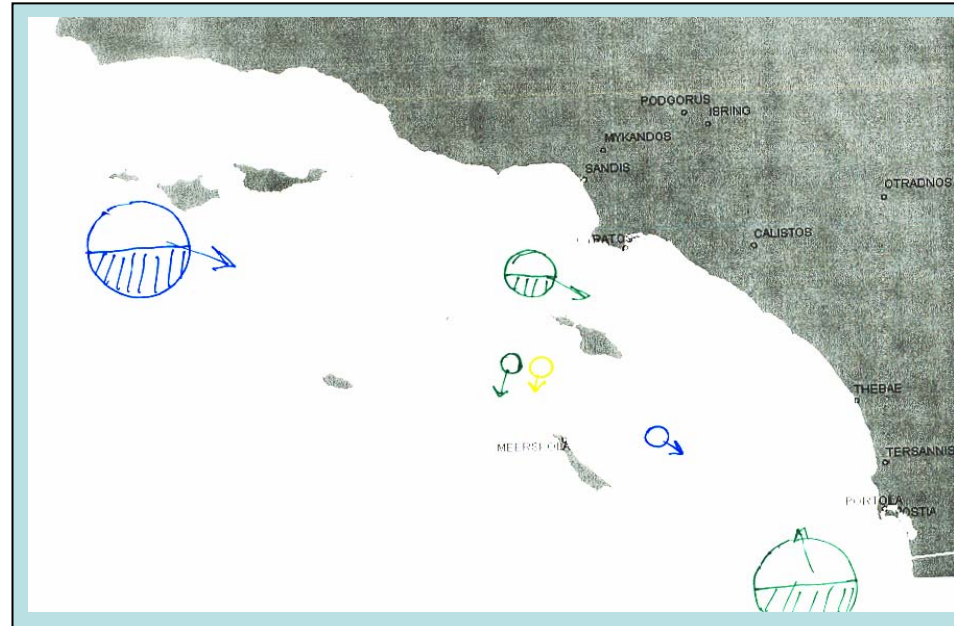
ESG

PHIBRON



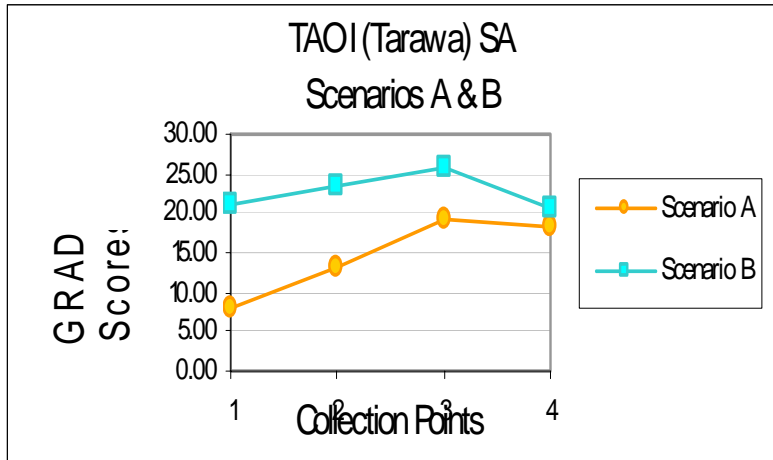
4 Data Pauses within each Segment (1/2/3) of each Scenario (A/B/C)

# GRADE

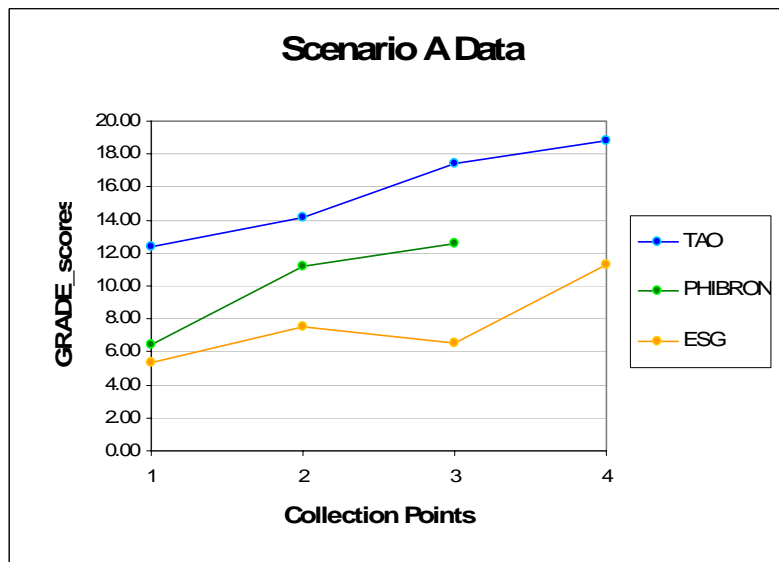




# Results



- **Chart I** – progression of GRADE scores from Scenarios A to B



- **Chart II** – variation in GRADE scores among different watch stations (TAO/ESG/PHIBRON)

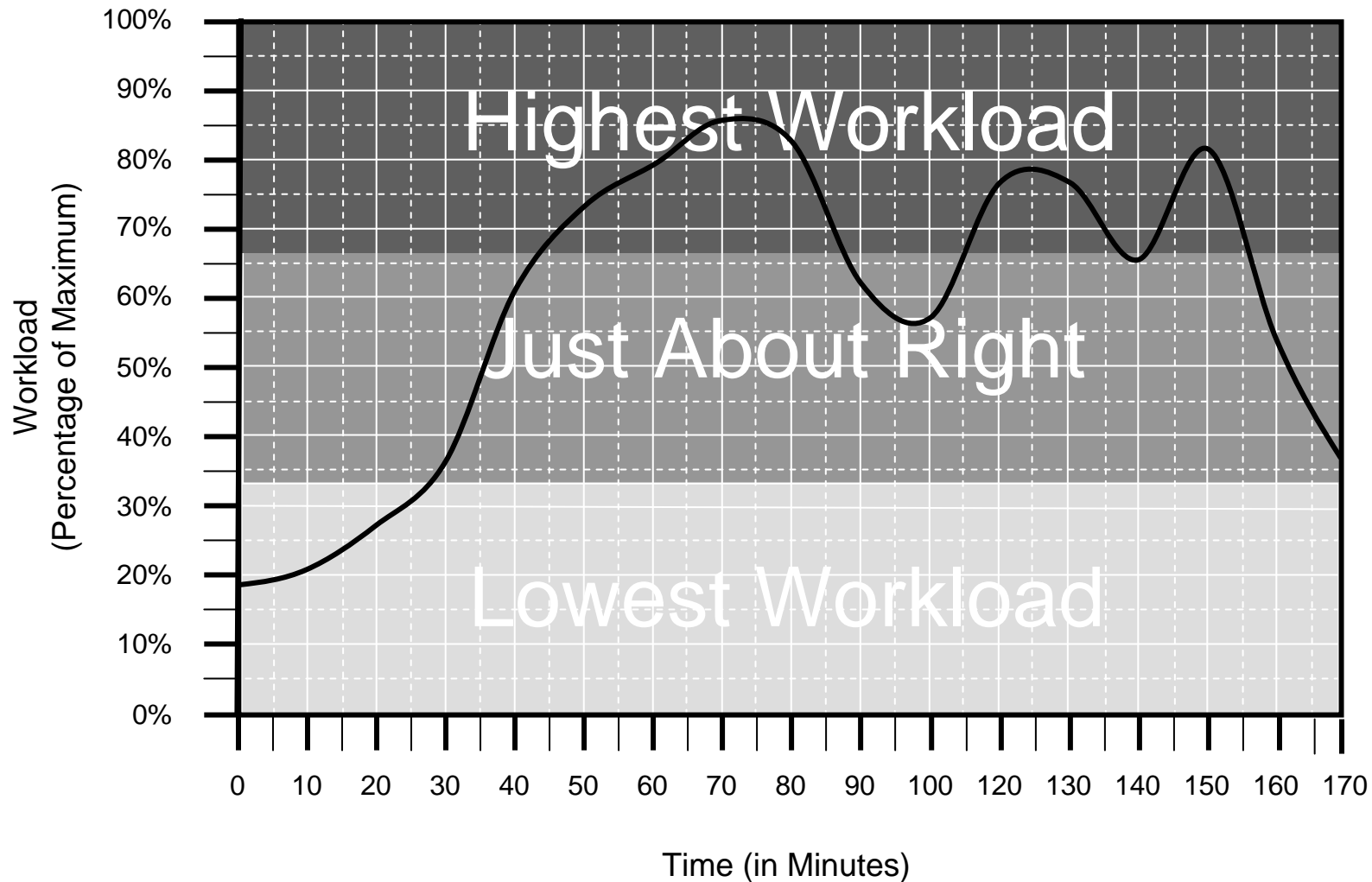


# Sample Heart Rate Variability





# Subjective Workload Assessment Graph (Cognitive) (SWAG-C)





# Summary



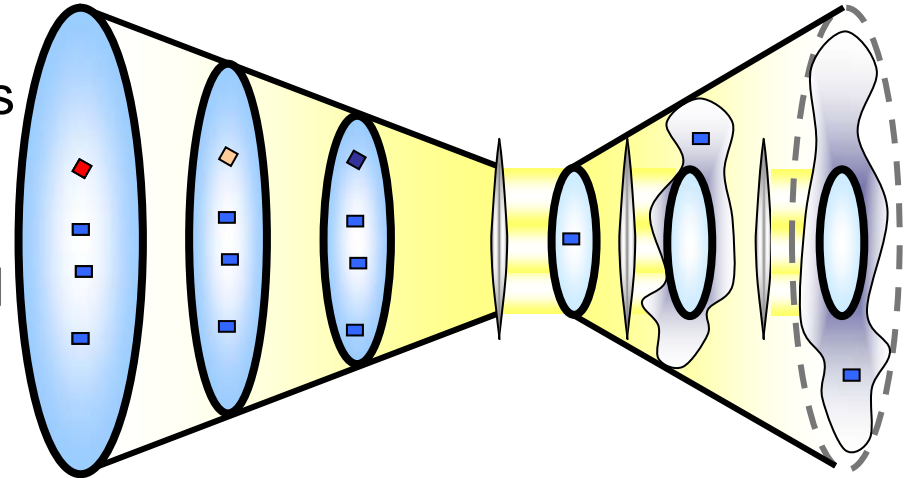
❑ The case of the *USS Stark* illustrates the **utility of the process model** of situated cognition as a descriptive and explanatory tool for both individual and collaborative activities.

❑ The model **combines both human and machine** system components.

❑ By employing multiple methods of data collection, **the evolution of an event can be traced** as data and information flow through the machine and human components of the system.

❑ The model **facilitates determining when and how activities go awry**.

❑ Knowledge of how and when errors occur is **critical to the design of new C2 systems** and the re-design of existing systems.





# **A Process Model of Situating Cognition in Military Command and Control**

Collaboration and Knowledge Management  
Workshop

11 - 13 January 2005  
San Diego, CA

**Nita Lewis Miller**  
**Naval Postgraduate School**  
**Monterey, CA**

**Lawrence G. Shattuck**  
**United States Military Academy**  
**West Point, NY**